Land-Use/Land Cover Analysis Through Object Based Technique: A Case Study of Shahrah-e-Faisal

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Abstract. Karachi is the major financial hub of Pakistan. The urban sprawl generates many sub financial hubs as well e.g. Saddar which is consider as CBD of metropolitan, specifically area along I.I. Chundrigar road is almost have offices and business set-up. The similar pattern has been emerged in many other places e.g. Shahrah-e-Faisal and Tariq road. Along all three major roads mixed-used development particularly commercialization has taken place prominently and these sectors emerged as main business Centre. The present study was aimed to assess the Land-Use/Land Cover (LU/LC), green cover and air quality index analysis through object based analysis on very high-resolution satellite imagery at Shahrah-e-Faisal. The obtained results showed that the combine three activities such as Shopping, Business and Trade (SBT), Social, Institutional and Infrastructure related activities (SII), and travel or movement (ToM) were occupied on 51.34% of land. The residential activities also make an attractive volume of proportion was up to 47.11%. Therefore, it can be the perfect example of smart growth if introduction greenways initiate more effectively along with some attraction spots for Leisure.

Keywords: Mixed-Used Development, Business Centre, Land-Use/Land Cover, Object Based Analysis, Smart City Growth, Greenways.

1. Introduction

The growing urbanization trend over the eras has caused in the rapid transformation of Land-Use and Land Cover (LU/LC) patterns global (Krishnan & Firoz, 2021). Land-Use Land Cover Change (LU/LCC) is the change of the Earth's surface by human being (Alsharif et al., 2022). LU/LCC is one of the prime suppliers of greenhouse gas frameworks subsequent from straight human use of lands for viable uses, settlements, and forestry activities (Kim & Kirschbaum, 2015). According to the census 2017, the metropolitan city of Karachi is the residence of 16,051,521 (Sohoo et al., 2021). Karachi is considering as a revenue-generating hub, significantly subsidizes wealth at provincial, and ultimately

on national level according to Karachi Master Plan 2007 and 2020. The built-up area of Karachi metropolitan comprises 1,300 km^2. In year 2013, the urban extent of Karachi was 45,327 hectares. By the year 2020 Metropolitan's average growth rate was about 2.27% (Nizamani, 2020). By assumed estimates, Karachi was grown 523.1 km^2 in 2020 and 543 km^2 in 2022. Being growing too fast Karachi is serving not only urban and sub urban neighborhood but also serves province and country as well. Being highest spatially interacted metropolitan Karachi has multiple Business sectors including Central Business District i.e. Saddar (Kausar et al., 2022), shopping business and trade activities along Tariq Road, and Shahrah-e-Faisal. Worldwide in developed cities planning strategies for the smart growth have been adapted. if the region is well connected with the neighborhood it means the region is smartly growing. Smart growth is important and modern planning strategy. This strategy emphasized on transit orient designs, walkable distances friendly designs with mixed land-use development etc. (Shrivastava & Sharma, 2012). This strategy gives a lift to its neighborhood regions as well. Housing choices will increase to citizens and new business set up may enhanced. There is a substantial gain in acceptance in contemporary mixed-used development concept (Tilley, 2016). Mixed-used development is more ecologically approachable and economically effective development instead of single-use properties (Rabianski et al., 2009). Existing research also find a presence of mixed-used development in study area.

With the development along the Shahrah-e-Faisal the risk of air pollution is getting worse, which ultimately effects on the quality of air. Air quality can assess through the Air Quality meter. According to US EPA standards 2016, the air quality meter worked on the criteria in which AQI values divided into six classes i.e., 1-50, 51-100, 101-150, 151-200, 201-300, and 301-500. These classes are categorized and demonstrated by specific color i.e. Good (Green), Moderate (Yellow), Unhealthy for sensitive group (Orange), Unhealthy (Red), Very unhealthy (Purple), and Hazardous (Maroon) respectively (EPA, 2022). In the former studies, Ban et al. (2010) performed the Quickbird multi-spectral data, multi-temporal RADARSAT Fine-Beam C-HH synthetic aperture radar (SAR) data and fusion of Quickbird MS and RADARSAT SAR for urban LU/LC mapping. Hu and Ban (2008) investigated the potential of high-resolution SAR data for urban LU/LC mapping by assimilating support vector machines (SVMs) into object-based analysis. Tehrany et al. (2014) examined the comparison between object and pixel-based classification methods for LU/LC mapping via SPOT 5 imagery. Recently, Alsharif et al. (2022) reported that the LU/LCC and urban growth prediction and analysis methods that can help in decision-makers for better sustainable management and planning of socioeconomic development

in the states. This research work may provide innovative and creative in the study area regarding analysis of LU/LC and assessment of air quality of study area. The main objectives of study were a) to identify LU/LC of Shahrah-e-Faisal through object based Analysis and Classify land-use on LBC's (land based classification) format, 2) assessment and relationship of Green Cover of AOI (Area of Interest), and 3) examine Air Quality Index along the study area.

2. Materials and Methods

2.1. Study Area

The existing research was based on LU/LC Analysis buffer area of 200 meters along both sides of Shahrah-e-Faisal. Shahrah e Faisal is major road of Karachi connecting more than ten major and many minor roads. The total length of Shahrah-e-Faisal is 18 km (11 mile). It connects with Saddar that is the historical and financial hub through ages (Fig. 1).

2.2. Study Plan

In the present work, the methodological framework is mentioned in Figure 2, which comprises material and methods adapted during research. The object-based analysis have been conducted on very high-resolution SAS Planet image, which was about 0.07 m/pixel. The objects were identified visually (manually), later digitized on the R.F. of 1:25-1:500 and then geo-coded through the information extracting from open domains e.g. GoogleEarth, Wikimapia and Google maps. Objects those cannot be confirmed/ identified; they later documented through field surveying. Air Quality Index (AQI) PM2.5 have been examined for the 13 spots of study area i.e., Shahrah-e-Faisal through the instrument UNI T UT338C air quality meter. It is the 20 days average on Roads Intersection (nodes) along Shahrah-e-Faisal for the month of November 1-20, 2022. Interpolation on IDW method through the ArcGIS have been adapted for generalization.

3. Results and Discussions

3.1. Land-Use/Land Cover Analysis

LU/LC analysis on the procedure of object based analysis has been conducted on Shahrah-e-Faisal and most of the remarkable fact found there is no industrial, manufacturing and waste related activity along the 400 meter (200 meter on each side) range. Which is in fact a good sign of development (Table 1 and Fig. 3). Total 5,075,838 m^2 area have been
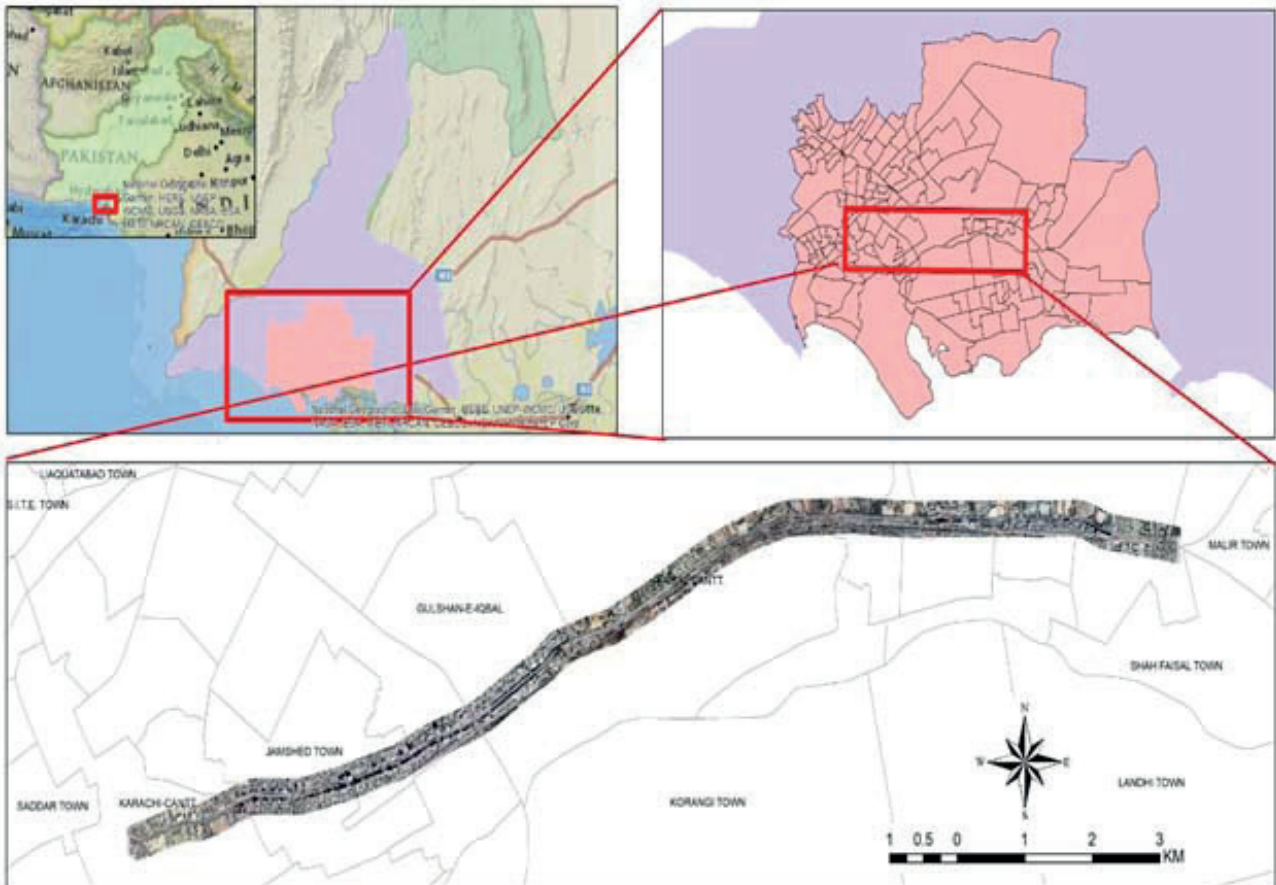
SHAHRAH-E-FAISAL: KARACHI METROPOLIS

Figure 1. Study Area: Shahrah-e- Faisal: Karachi Metropolitan
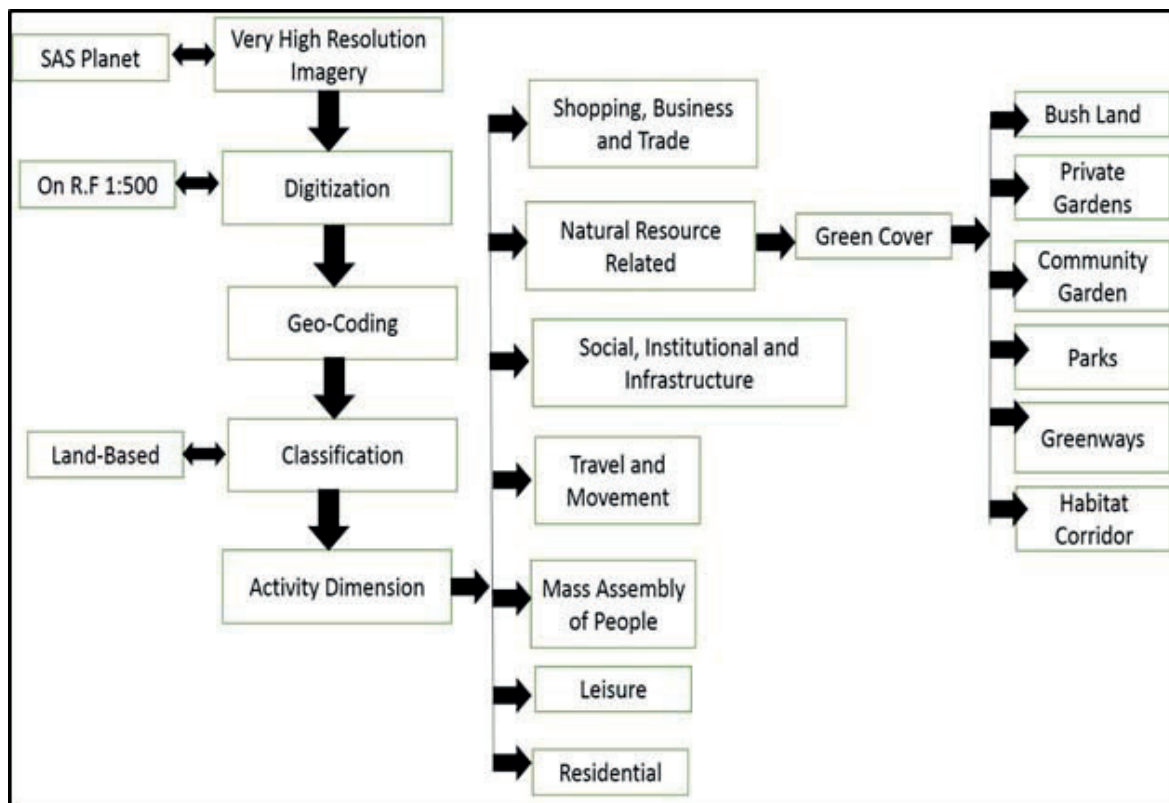

Figure 2. Methodological Framework for LU/LC

assess excluding roads coverages. Approximately, 10.04% land was occupied by Shopping, Business and Trade (SBT) activities (Table 1). Moreover, 22.4% land was occupied by Social, Institutional and Infrastructure (SII) base activities (Table 1). Travel or movement (ToM) activities occupied distributed on 19% of land across the major road (Table 1). Three activities (SBT, SII and ToM) collectively occupied on 51.34% of land. Residential activities also make an attractive volume of proportion i.e. 47.11% (Table 1). Residential activities along with Shopping, Business and Trade, Social, Institutional and Infrastructure and Travel or movement fit on the definition of smart growth and best Transit orient design (TOD) i.e. Shahrah-e-Faisal connected almost all major and minor roads derives from almost entire Karachi metropolis and from even sub-urban zones Figure 4a,b and Figure 5. Mass assembly of people (MAP), Leisure Activities (LA), and natural resources related activities are very less in present area of interest i.e. 1.57%. Many reasons can might be possible for such percentage and the prime most is high land value in real estate business (Table 1). Hu and Ban (2008) revealed that the method could achieve a high accuracy for the classification of high-resolution SAR images over urban areas. Tehrany et al. (2014) suggested to test on very high resolution (VHR) data such as SPOT 5 image especially in built-up area where more and varied classes can be generated.

Table 1. Land-Use/Land Cover Analysis

S. No.	Activity Type	Area (m^2)	Percentage (%)
1	Residential activities	2,391,184	47.109
2	Sopping, Business or Trade activities	509,718	10.042
3	Industrial, Manufacturing and waste related activities	0	0.000
4	Social, Institutional or infrastructure related activities	1,136,052	22.381
5	Travel or Movement activities	959,169	18.897
6	Mass Assembly of people	64,556	1.272
7	Leisure activities	13,589	0.268
8	Natural Resources related activities	1,563	0.031
9	No Human activity or Unclassifiable activities	7	0.000
	TOTAL	**5,075,838**	100.000

In present study Green Cover in study area is comprises approximately 1,804,310 m^2. Green Cover further sub divided into six classes i.e. Bush Land, Community Gardens, Private Gardens, Parks, Green Ways and Habitat Corridors i.e. the covered area estimated 30.040%, 6.072%, 32.635%, 0.475%, 27.145% and 3.633% respectively (Table 2). In present study, the total LU/LC which was observed by 6,880,148 m^2 area (Table 1 and 2). In which LU/LC (Table 1) excluding green
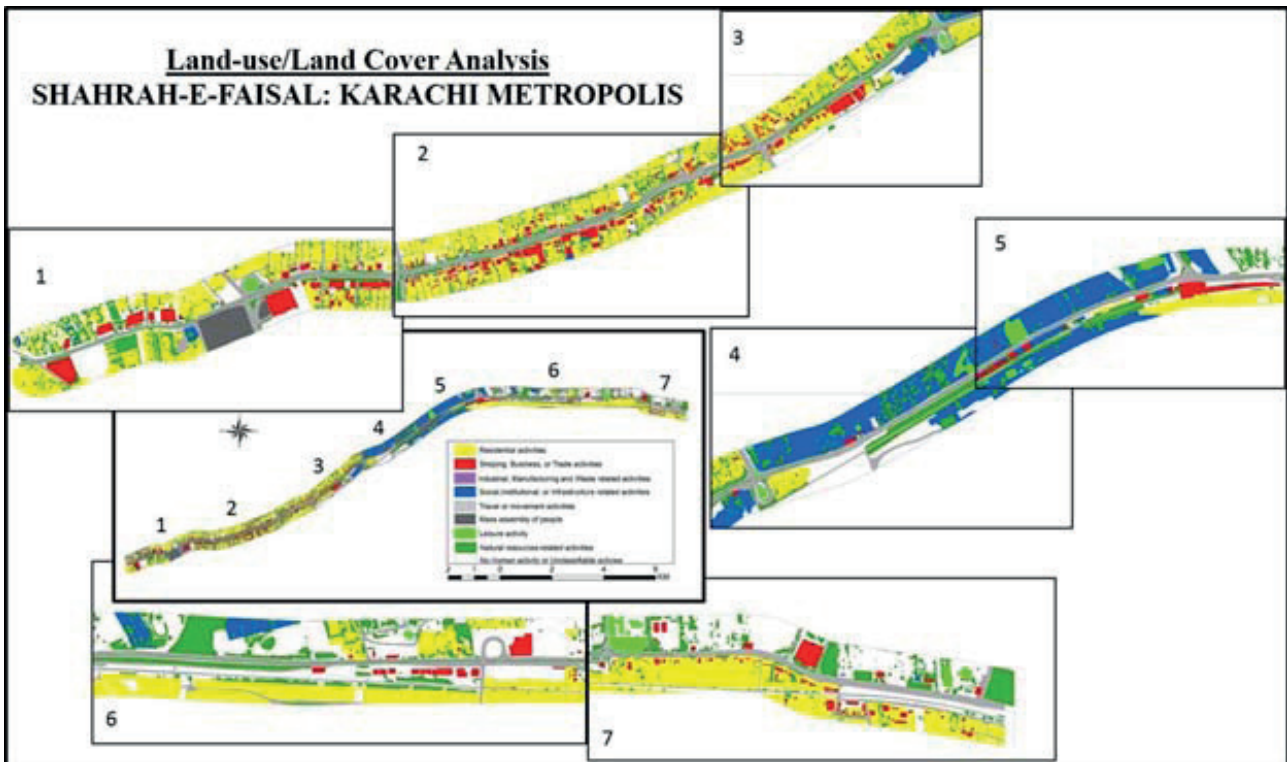

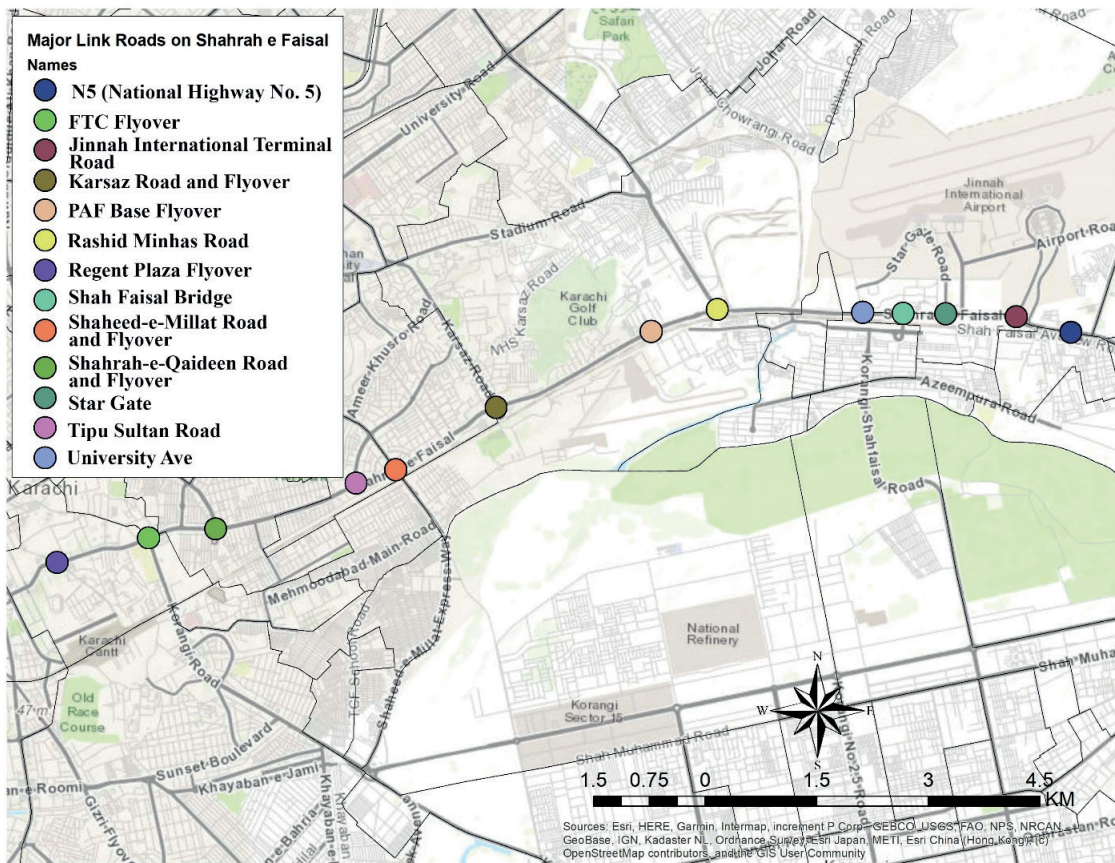**Figure 3.** LU/LC mapping along Shahrah-e-Faisal

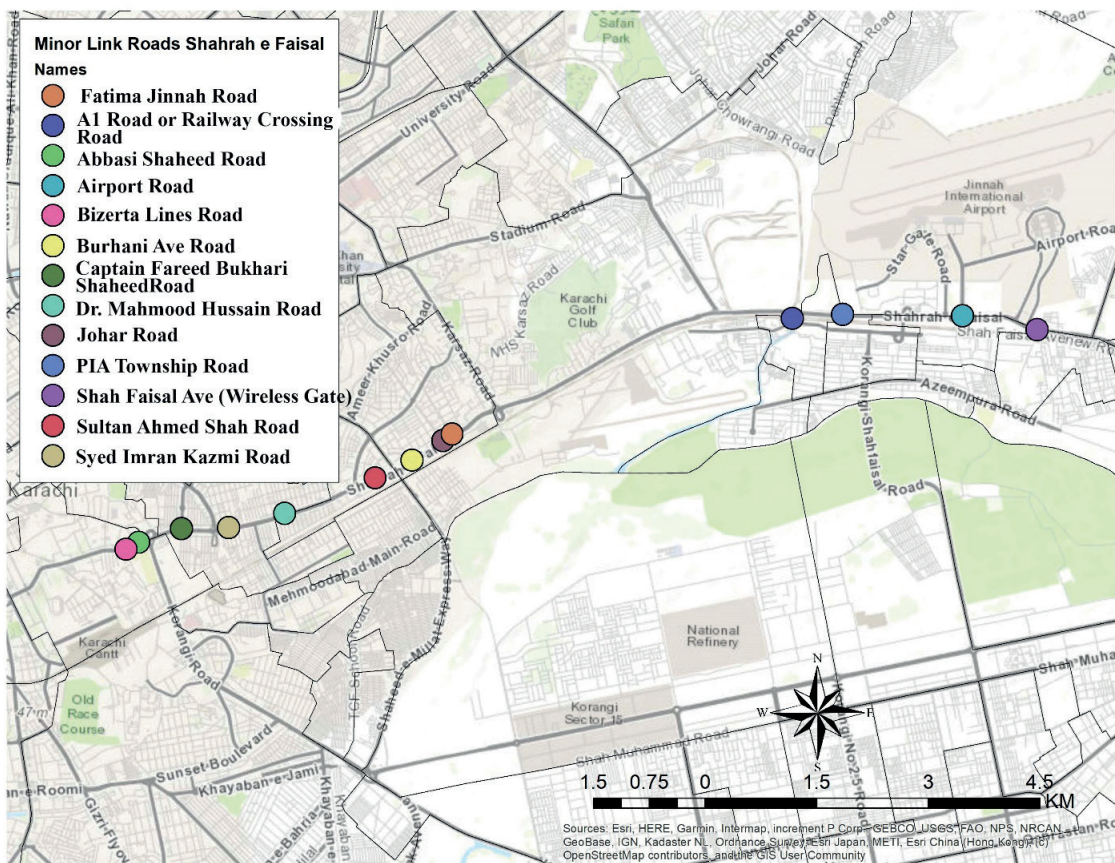**Figure 4a.** Connectivity of Shahrah-e-Faisal with Major Road
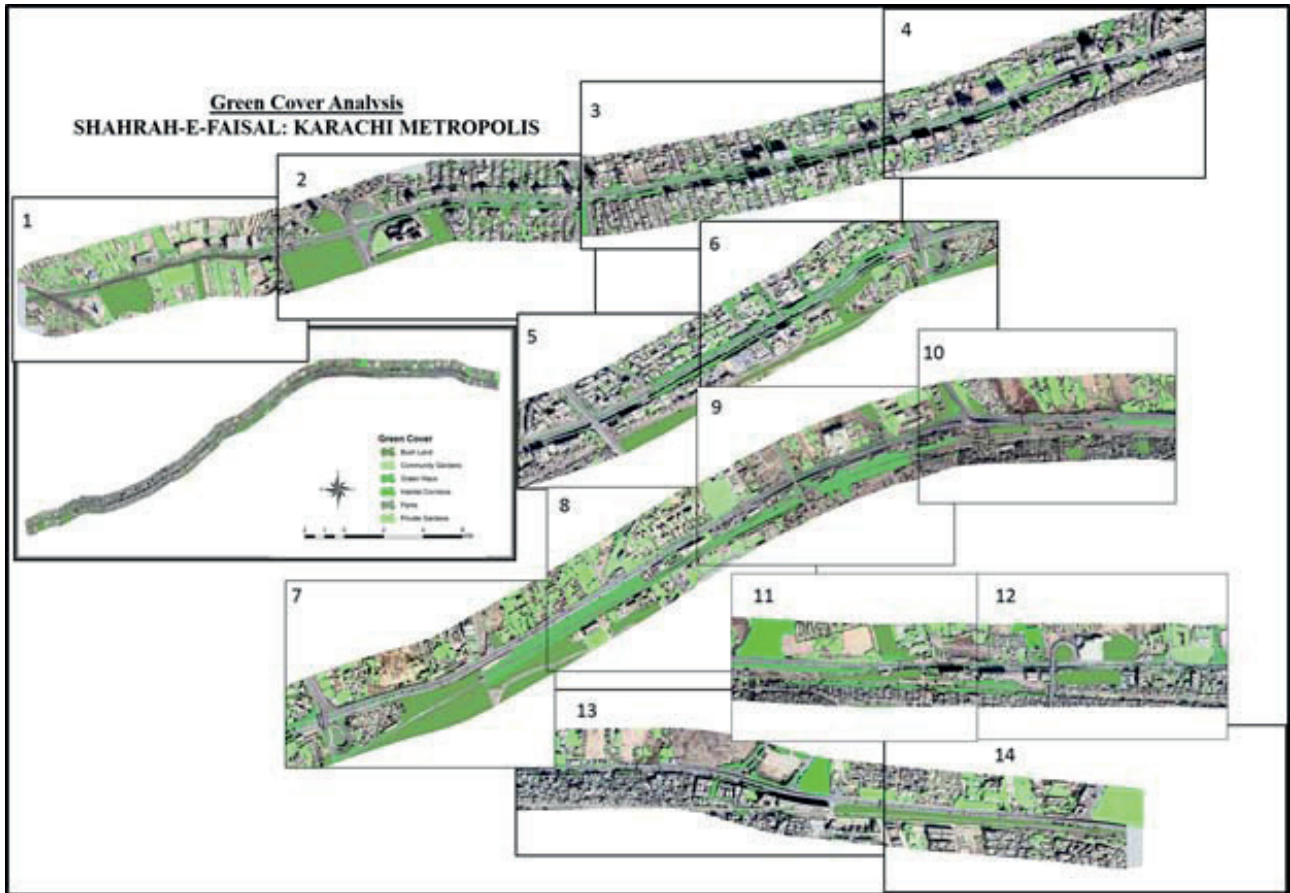

Figure 4b. Connectivity of Shahrah-e-Faisal with Minor Roads

Figure 5. Green Cover of Shahrah-e-Faisal

cover contributes 5,075,838 m^2, which is about 73.77% while green cover contributes 1,804,310 m^2 which is around 26.22% (Table 2). Shrahily et al. (2022) conducted a study in the Al-Khobar region (Saudi Arabia) using Landsat databases, as a result the built-up areas enlarged by 117% and 43.51% among 1990–2001 and 2001–2013 respectively.

Table 2. Green Cover Type of AOI

S. No.	Green cover Type	Area (m^2)	Percentage (%)
1	Bush Land	542,020	30.040
2	Community Gardens	109,561	6.072
3	Private Garden	588,843	32.635
4	Parks	8,562	0.475
5	Green Ways	489,777	27.145
6	Habitat Corridors	65,547	3.633
	TOTAL	**1,804,310**	100.000

3.2. Air Quality Index

Green cover is an important planning strategy of recent era and importance of green cover can easily be evaluated through the condition of Air Quality of study area. For this on Shahrah-e-Faisal we selected some spots on where measurement of Air Quality Index will be conducted. Spots which were selected are those where different major roads intersect or connect or created node on Shahrah e Faisal (Fig. 4a,b). These spots are as follows (Table 3,4). Krishnan and Firoz (2021) stated that the LU/LC analysis exposed a rise in the settlement over the past two eras.

Through the interpolation techniques, 13 spots were examined for assessing air quality index (AQI) pm 2.5. Six different timings with the interval of 4 hours have been selected i.e. 8am, 12pm, 4pm, 8pm, 12pm and 4am. The best Air quality have been recorded on all spots at 4am morning. Minimum AQI i.e. 5,5 are recorded Shahrah-e-Quaideen node and Rashid Minhas node followed by PAF Base Flyover node i.e. 6 (Fig. 6, Table 3,4). These all nodes have large green cover areas in the surroundings. In case of less or absence of traffic on Shahrah-e-Faisal AQI of study area become innocuous. After 4am, at morning 8am; AQI reading have been enhanced and highest reading have been recorded at Star Gate, followed by Shaheed e Millat nodes (Fig. 6 and Table 3). It clearly reflects these nodes have heavy traffic on the routes on which these nodes exist. High AQI readings have been started to record at 12pm and it becomes at its highest around 4pm an evening time

Table 3. 20 days' average of Air Quality Index (pm 2.5) on Roads Intersection (nodes) along Shahrah-e-Faisal for the month of November 1-20, 2022

S.No.	Map Coding	Locations	12am	4am	8am	12pm	4pm	8pm
1	12	N5	10	12	65	178	287	134
2	7	FTC Flyover	20	10	74	201	300	153
3	11	Jinnah International Terminal	45	13	99	185	315	110
4	4	Karsaz Flyover and Road	34	17	97	200	250	137
5	10	PAF Base Flyover	52	6	83	245	274	161
6	3	Rashid Minhas Road	10	5	82	184	200	158
7	8	Regent Plaza Flyover	40	9	45	192	214	109
8	1	Shah Faisal Bridge	36	10	50	137	269	151
9	5	Shaheed e Millat Road and Flyover	25	16	102	241	302	130
10	6	Shahrah e Quaideen Road and Flyover	20	5	85	204	198	110
11	0	Star Gate	56	10	114	169	149	154
12	9	Tipu Sultan Road	40	14	64	100	286	116
13	2	University Avenue	25	13	81	185	200	100

Table 4. Air quality index scale and color legends

AQI Range	Color	Air Pollution Level	Cautionary Statement (For PM 2.5)
1-50		Good	None
51-100		Moderate	Harmful for Sensitive People
101-150		Un Healthy for Sensitive Group	Harmful for Sensitive People
151-200		Un Healthy	Not good for everyone
201-300		Very Un Healthy	Not good for everyone
301-500		Hazardous	Health Alert. Avoid outdoor Activity
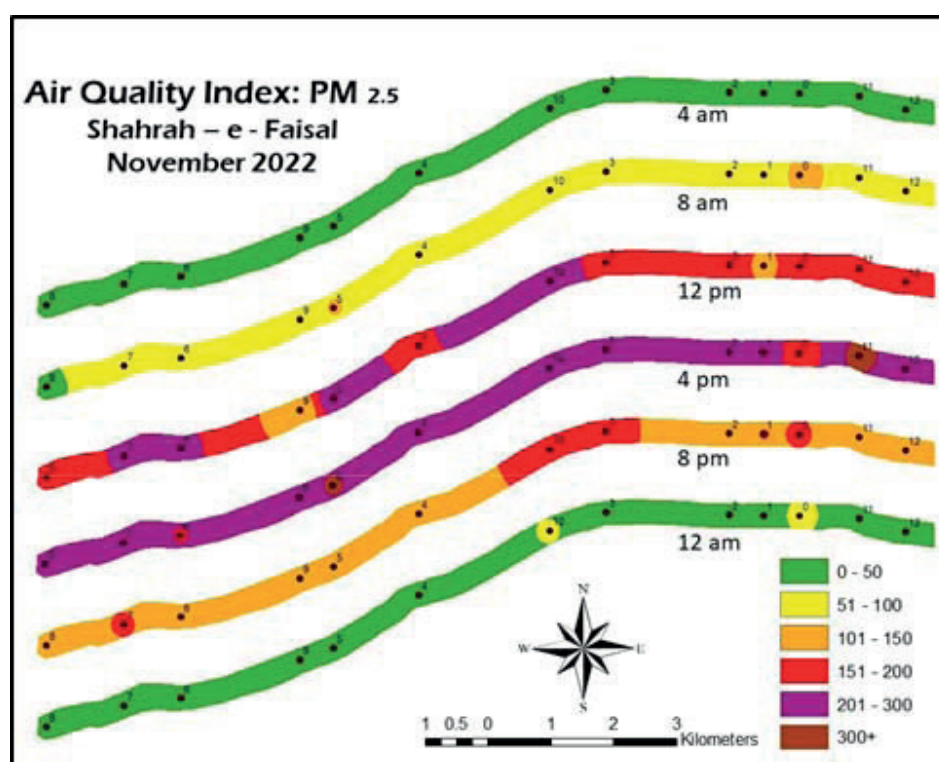
Figure 6. Air Quality pm 2.5 of selected spots on different timings

(Fig. 6). The highest peak of AQI vulnerable reading is 315 near Jinnah International Terminal node i.e. 315 the second highest vulnerable peak have been recorded at FTC node. It is therefore a dire need of introducing more trees near Jinnah International Terminal node as well as FTC node to improve air quality. Over all maximum vulnerable situation on nearly all over the Shahrah-e-Faisal have been recorded at 4pm (Fig. 6 and Table 3). Xian (2007) examined the multi-year data from local air monitoring stations during May and June timeframe, the results revealed that the minimum concentrations generally occur from November to February, but the fine particulate matter maximum was occurs in the month of July.

4. Conclusion

This research has attempted to demonstrate the mixed-used development of residential, shopping, business and trade, social, institutional and infrastructure and travel or movement reflects the pattern of smart growth along with an efficient Transit orient design (TOD) i.e. Shahrah e Faisal connected with almost all major and minor roads within metropolis and its exit routes. The aggregate LU/LC of study area, which was under assessment cover 6,880,148 m^2 area i.e. 73.77% while green cover area was calculated an approximately 1,804,310 m^2 of area i.e. 26.22%. Air Quality is vulnerable in rush hours i.e. 12 pm to 4 pm while at 8pm and onward the situation become regularized. Over all in rush hours, AQI pm 2.5 increased at rapid rate. Such case reflects Shahrah-e-Faisal required more greenways (greenbelts) within the Shahrah-e-Faisal.

Suggestion and future perspectives. Mixed-used development is a positive sign of development. All over the world, developed cities are associated with smart implication of planning strategies. This intact city growth and lead to reduce urban sprawl. Shahrah-e-Faisal is well connected with the rest of the metropolitan, and there is a project of Red Line Bus Rapid Transport (BRT), in which the route 1 is operation, which connected the Shahrah-e-Faisal at the node of Malir Halt. It is the best way of introducing transit orient design in already developed infrastructure. Land-use along the Shahrah-e-Faisal can be more commercialized due to its higher connectivity of major, minor routes/roads and BRT. Green cover area is not sufficient along the road, which may causing health issues as well. For this auxiliary Green cover should be introduce along the roads. Cutting of already, existing trees should be prohibited.

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